Bringing the Full Power of Modern Hardware to the Open Web Platform

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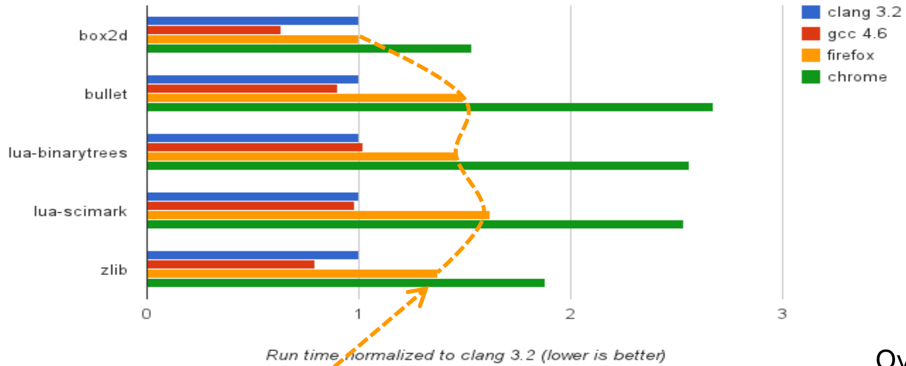
Astounding JavaScript* Performance Improvements



Very efficient code generated by Firefox* JIT

LLVM Bitcode

Emscripten

JavaScript*
asm.js

Epic* Games Unreal Engine* 3

http://www.unrealengine.com/html5/

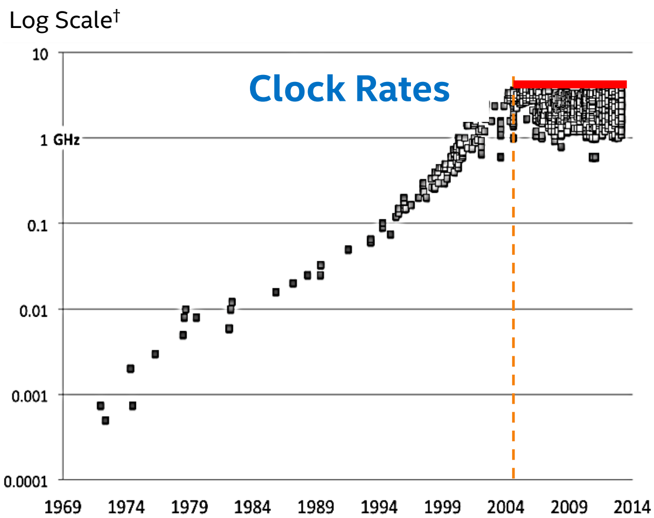
Over 1M lines of C/C++ code compiled to JavaScript* by Mozilla* and Epic

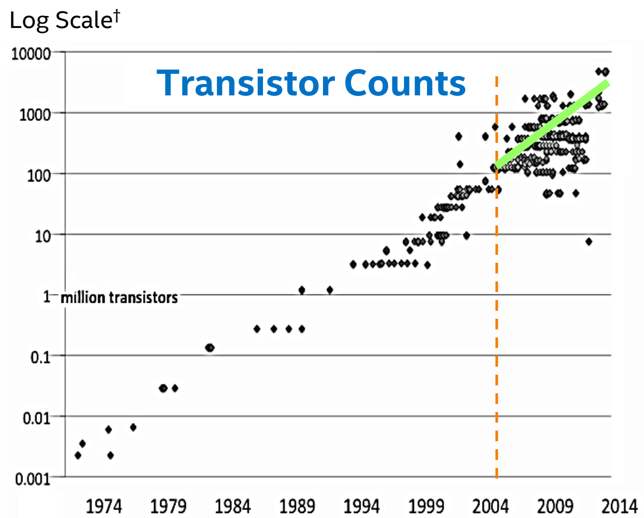
Achieving ~ 1.5x native running time via targeting asm.js†, a highly optimizable subset of JavaScript

JavaScript performance is approaching native speeds

† Courtesy of Mozilla Alon Zakai & Luke Wagner: http://people.mozilla.org/~lwagner/gdc-pres/gdc-2014.html#/

Microprocessor Trends – “Free Lunch” is over!





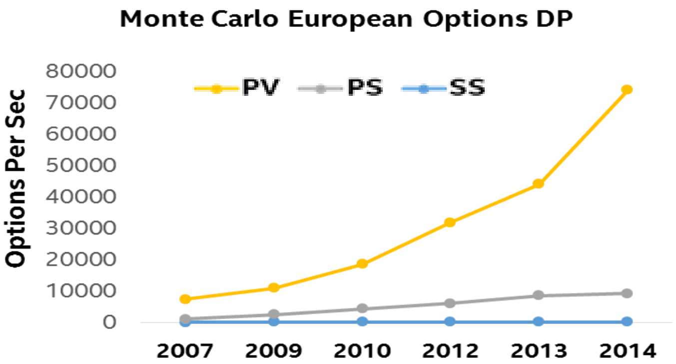
- Growth in processor clock rate halted around 2005
- Transistors per processor continues to grow exponentially

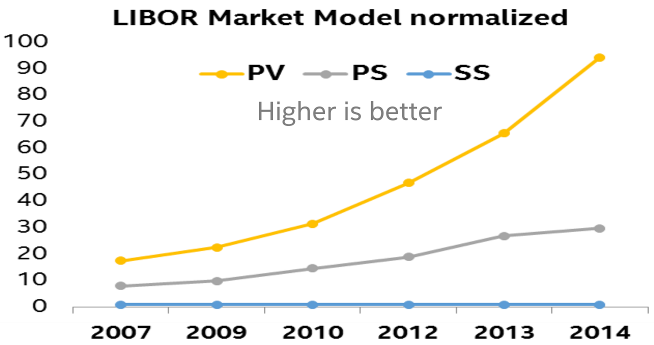
But, Moore’s Law continues with a shift to parallelism

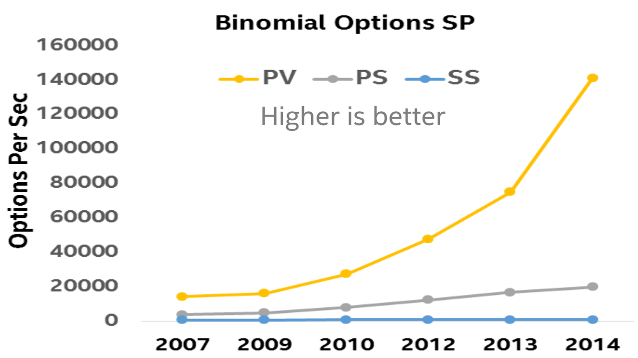
† (c) 2013, James Reinders and Jim Jeffers: *Intel® Xeon Phi™ High-Performance Programming*, used with permission.

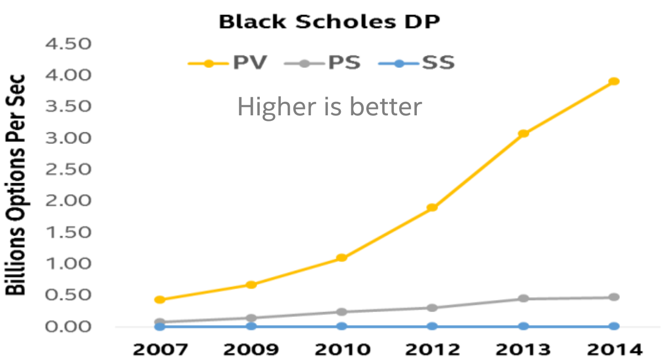
Parallelism is now Required to Benefit from Moore's Law

SS: Sequential Scalar **PS:** Parallel Scalar **PV:** Parallel Vector





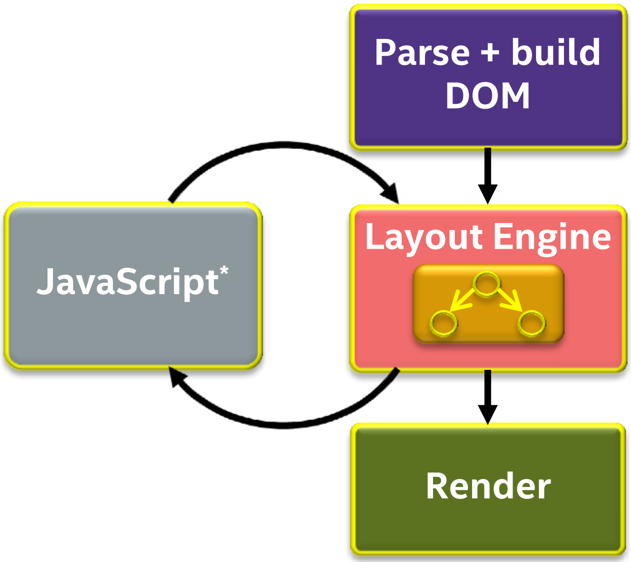


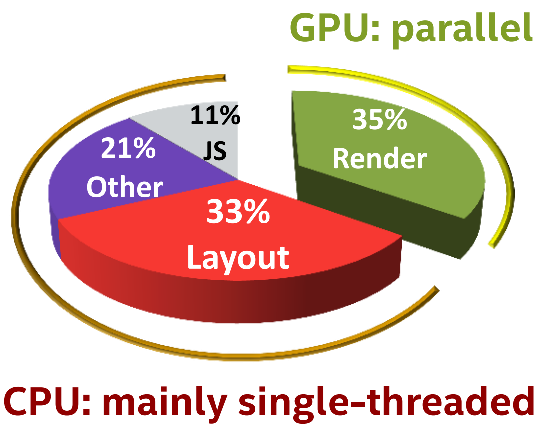


Open web client platform needs to be on Moore's Law curve

† Courtesy of Intel® Robert Geva: & Jim Jeffers: https://intel.activeevents.com/sf14/connect/sessionDetail.ww?SESSION_ID=1187

Optimizing Web Runtimes for Parallelism

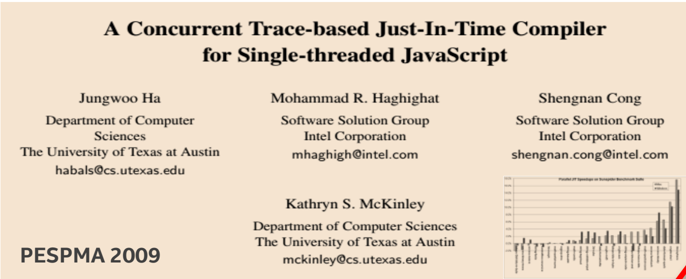




- HTML5 runtimes of today are not scalable with number of cores
- Need parallelism for both responsiveness and energy efficiency

Web runtimes need to be parallel end-to-end

Parallel Parsing and Compilation



A Concurrent Trace-based Just-In-Time Compiler for Single-threaded JavaScript

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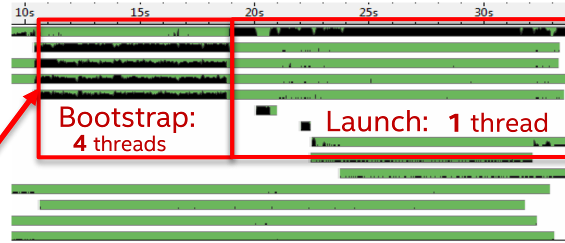
PESPMA 2009

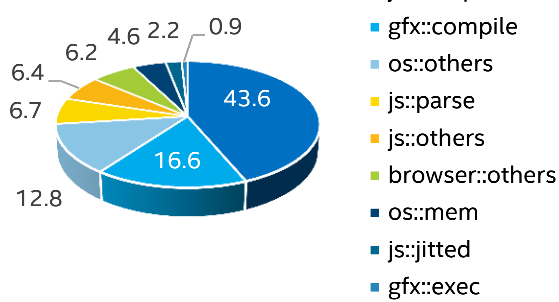


Epic* Citadel* profile on Firefox*

Process / Thread / Module / Function / Call Stack	CPU_CLK_UNHALTED.THREAD
firefox.exe	100.0%
Thread (0x11c0) JS and GFX execution	32.9%
Thread (0xfc)	19.1%
Thread (0x230)	14.5%
Thread (0xa00)	14.4%
Thread (0x148)	14.2%
Thread (0x480)	1.6%
Thread (0x10ec)	1.0%
Thread (0xf48)	1.0%
Thread (0x434)	0.7%
Thread (0x7c8)	0.3%
Thread (0x1344)	0.1%

Four threads for JavaScript* parsing and compilation

Cycle Breakdown



Background JIT compilers now in Chrome*, Firefox, Internet Explorer*, Safari*

SIMD – Single Instruction, Multiple Data

Scalar Operation

$A_x + B_x = C_x$

$A_y + B_y = C_y$

$A_z + B_z = C_z$

$A_w + B_w = C_w$

SIMD Operation of Vector Length 4 †

$$\begin{bmatrix} A_x \\ A_y \\ A_z \\ A_w \end{bmatrix} + \begin{bmatrix} B_x \\ B_y \\ B_z \\ B_w \end{bmatrix} = \begin{bmatrix} C_x \\ C_y \\ C_z \\ C_w \end{bmatrix}$$

SIMD operations deliver great performance & power efficiency

† Intel® Architecture currently has SIMD operations of vector length 4, 8, 16

Bringing SIMD to JavaScript*

Collaborators: Intel, Mozilla*, Google*, Microsoft*, ARM*, …

SIMD Number: http://wiki.ecmascript.org/doku.php?id=strawman:simd_number
Authors: Google's John McCutchan and Intel's Peter Jensen

Polyfill API: https://github.com/johnmccutchan/ecmascript_simd

float32x4, int32x4, Float32x4Array, Int32x4Array

```
var a = SIMD.float32x4 (1.0, 2.0, 3.0, 4.0);
var b = SIMD.float32x4 (5.0, 6.0, 7.0, 8.0);
var c = SIMD.float32x4.add (a, b);
```

Constructors: float32x4(x,y,z,w) float32x4.splat(s) float32x4.zero()

Operations: abs, neg, add, sub, mul, div, clamp, min, max, reciprocal, reciprocalSqrt, scale, sqrt, shuffle, shuffleMix, equal, notEqual, lessThan, greaterThan , withX, withY …

Status: In Firefox* Nightly, prototyped in Chromium*, on IEBlog roadmap£

1st stage approval for inclusion in ES7 by TC39†

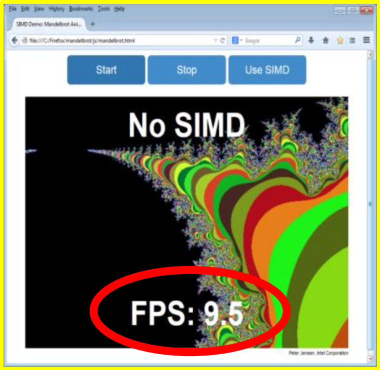
† A copy of the TC39 Presentation: http://esdiscuss.org/notes/2014-07/simd-128-tc39.pdf

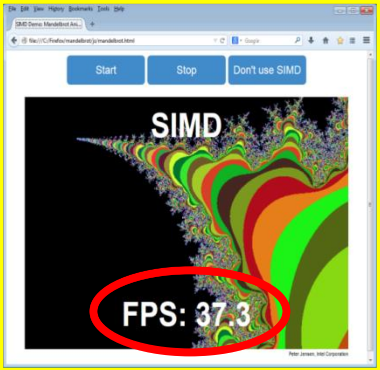
£ IEBlog: http://blogs.msdn.com/b/ie/archive/2014/09/18/updates-to-our-platform-roadmap.aspx

SIMD.JS – The API

```
function mandelx4(c_re4, c_im4) {
  var z_re4  = c_re4;
  var z_im4  = c_im4;
  var four4  = SIMD.float32x4.splat (4.0);
  var two4   = SIMD.float32x4.splat (2.0);
  var count4 = SIMD.int32x4.splat (0);
  var one4   = SIMD.int32x4.splat (1);

  for (var i = 0; i < max_iterations; ++i) {
    var z_re24 = SIMD.float32x4.mul (z_re4, z_re4);
    var z_im24 = SIMD.float32x4.mul (z_im4, z_im4);

    var mi4    = SIMD.float32x4.lessThanOrEqual (SIMD.float32x4.add (z_re24, z_im24), four4);
    // if all 4 values are greater than 4.0, there's no reason to continue
    if (mi4.signMask === 0x00) {
      break;
    }

    var new_re4 = SIMD.float32x4.sub (z_re24, z_im24);
    var new_im4 = SIMD.float32x4.mul (SIMD.float32x4.mul (two4, z_re4), z_im4);
    z_re4       = SIMD.float32x4.add (c_re4, new_re4);
    z_im4       = SIMD.float32x4.add (c_im4, new_im4);
    count4      = SIMD.int32x4.add (count4, SIMD.int32x4.and (mi4, one4));
  }
  return count4;
}
```

Our Firefox* Prototype



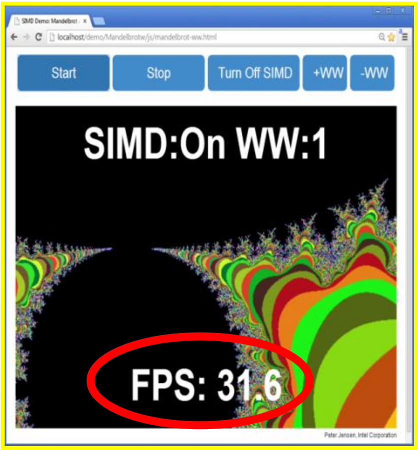


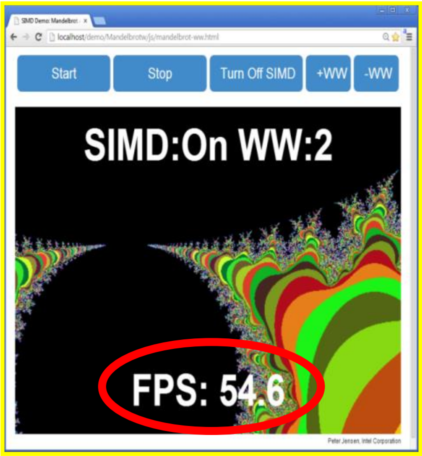
Our SIMD prototype delivers 3x~4x Mandelbrot speedup†

† Initial support for float32x4 and int32x4

Combining SIMD and Higher-Level Parallelism

WW: Number of WebWorkers



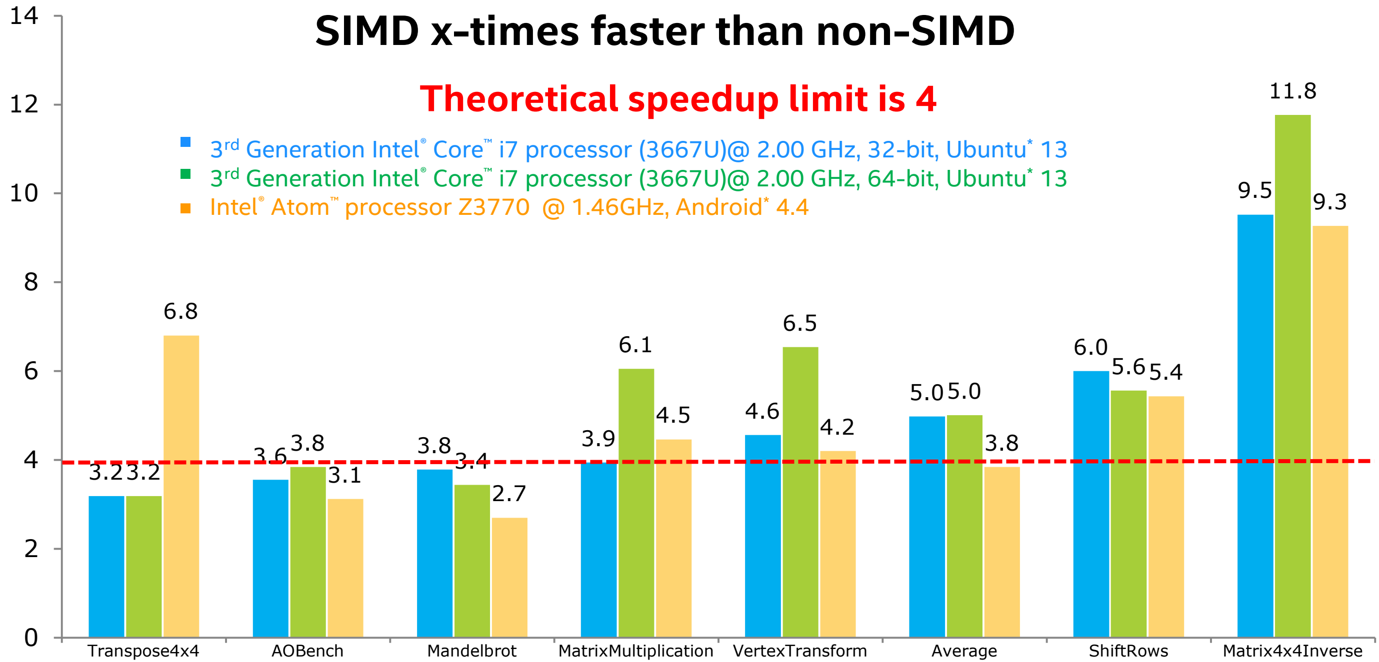


Our Chromium* Prototype

SIMD speedup is nicely multiplied by WebWorkers†

† Source: Intel® Peter Jensen : https://github.com/PeterJensen/
SIMD.JS demos: http://peterjensen.github.io/idf2014-simd

SIMD Speedups on Chromium*



Excellent early results while still focused on functionality

SIMD.JS benchmarks: https://github.com/johnmccutchan/ecmascript_simd/tree/master/src/benchmarks

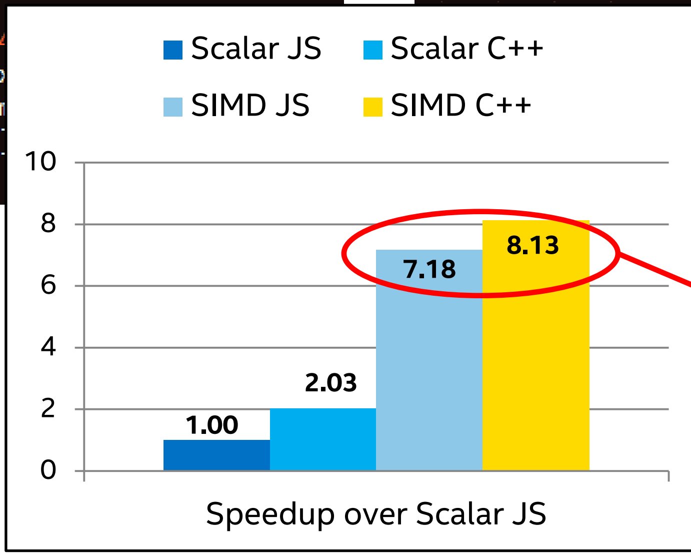
Emscripten now targets SIMD.JS

```
float simdAverage(float *src, int len) {
  __m128 sumx4 = _mm_setzero_ps();
  for (int i = 0; i < len; i+=4) {
    __m128 v = _mm_load_ps(src + i);
    sumx4 = _mm_add_ps(sumx4, v);
  }
  float sumx4_mem[4
  _mm_store_ps(sumx
  return (sumx4_mem
     + sumx4_mem[2]
}
```

C/C++

```
$16 = HEAP32[$src >> 2] | 0;
$i$02$i = 0;
$sumx4$01$i = SIMD.float32x4.splat(0);
$17 = $16 >> 4;
do {
 $sumx4$01$i = SIMD.float32x4.add($sumx4$01$i,
                   32x4[$17 + ($i$02$i >> 4)]);
                    + 4 | 0;
                   | 0) < 1e4);
                   Ptr >> 3] =
                    ($sumx4$01$i.z +
                    $sumx4$01$i.y))) / 1.0e4;
```

JavaScript*



Near-native SIMD.JS speedup

Emscripten brings native SIMD apps to the open web platform

Toward Perceptual Computing†

Learning & Education

Immersive Collaboration

3D Scanning and Sharing

Scan it

Share it

Customize and Print it

Gaming

Speech

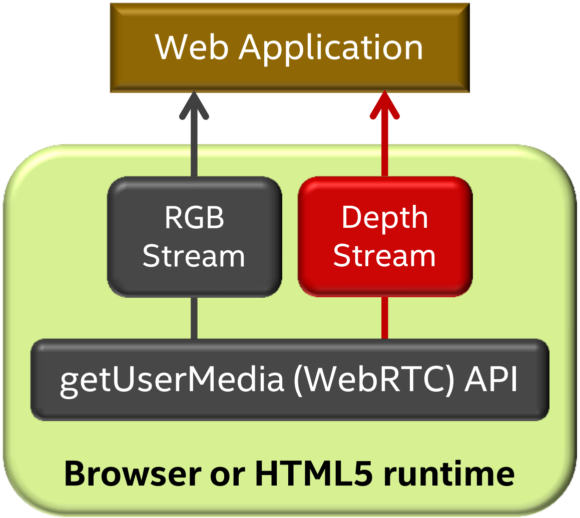
Out-of-reach Device Input

Devices sense and perceive user actions in a natural way

† Source: Intel® Perceptual Computing SDK: www.intel.com/software/perceptual

3D Cameras Make Perceptual Computing Accessible

Embedded 3D Camera

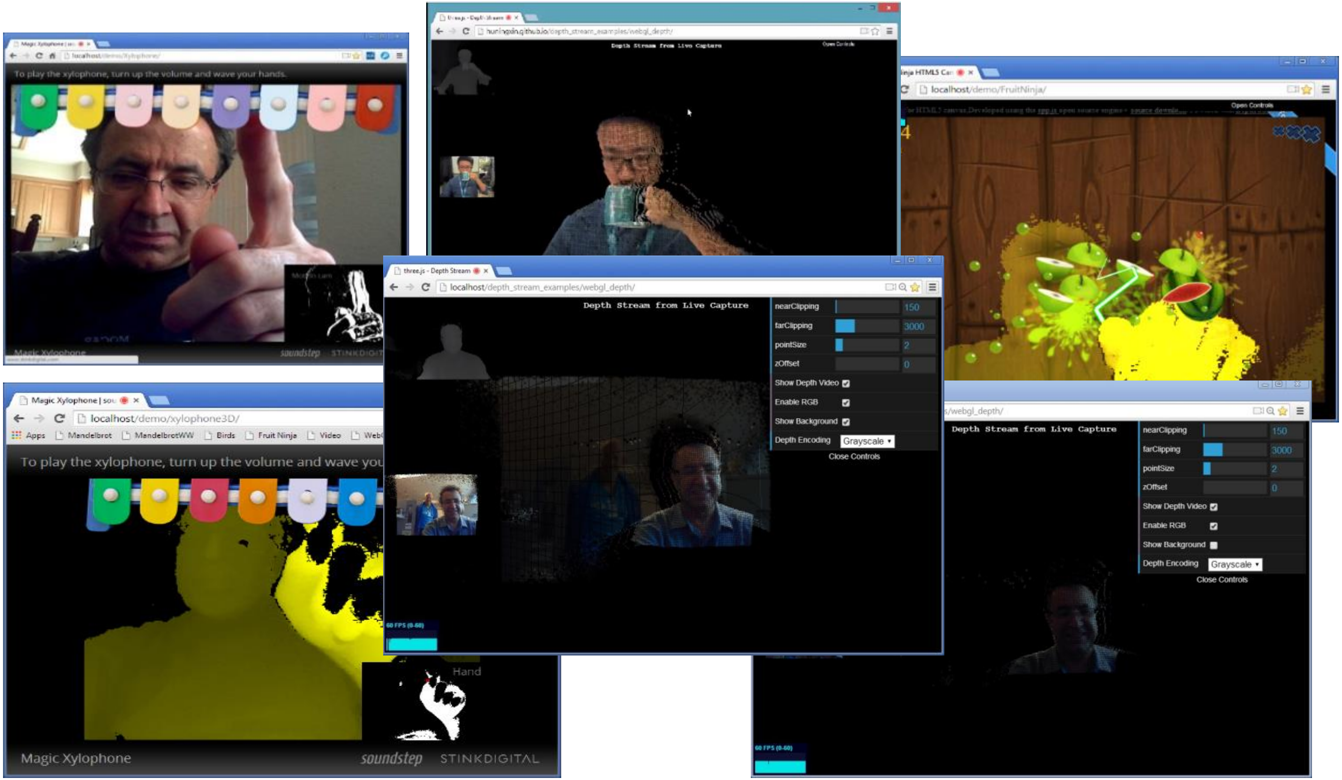



```
navigator.getUserMedia
  ({ video: true, depth: true }, success, failure);

function success(s) {

  var video = document.querySelector('#video');
  video.src = URL.createObjectURL(s);
  video.play();

  // construct MediaStream from the existing depth track(s)
  var depthStream = new MediaStream(s.getDepthTracks());

  // send the created depth stream over a RTCPeerConnection
  var peerConnection = new RTCPeerConnection(config);
  peerConnection.addStream(depthStream);

  var depthVideo = document.querySelector('#depthVideo');
  depthVideo.src = URL.createObjectURL(depthStream);
  depthVideo.play();
}
```

Media Capture Depth Stream Extensions are in W3C WG†

† W3C Media Capture Depth Stream Extensions: http://w3c.github.io/mediacapture-depth/

Toward Perceptual Web†



† 3D Camera WebRTC Demos, Courtesy of Intel® Ningxin Hu: https://www.youtube.com/channel/UC3eppo33tlz_EP7NWtZc0jQ
Demo Sources: Intel® Ningxin Hu: https://github.com/huningxin/depth_stream_examples
WebRTC Google* Code: http://webrtc.googlecode.com/svn/trunk/samples/js/demos/html/
Magic Xylophone: Soundstep*.com: http://www.soundstep.com/blog/experiments/jsdetection/

Web: The Most Viable Cross-Platform Technology Today

Visual, Perceptual, Full HW Access

and the Ubiquitous Application Platform of the Future

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